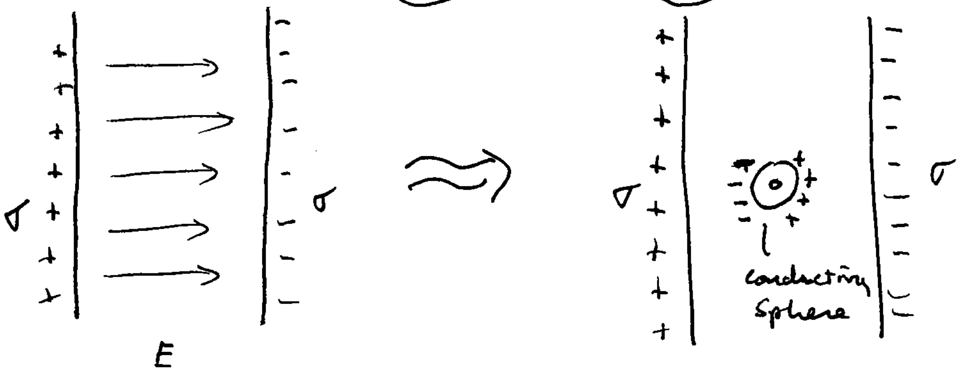
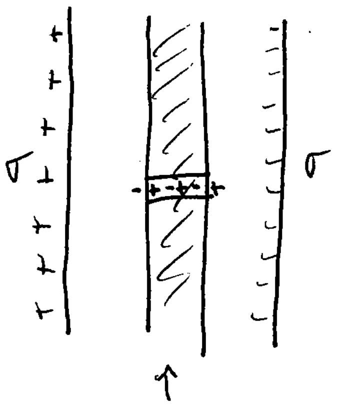
# Dielectrics - insulator - charges do NOT flow freely

Polar vs. nonpolar

can become polarized




Force between plates (E field) increased due to induced charges



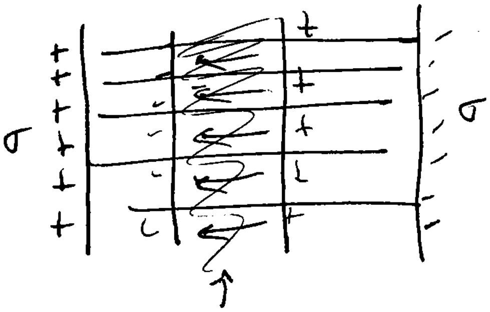

water

dipoles line up ... get induced surface charge

Again E at plates increased slightly

(Less than if had placed conductor)

But inside dielectric




E is reduced

So, can reduce E between plates by filling w/ dielectric

So

$$|E| = \frac{\sigma}{K \epsilon_0}$$

reduced by $K \equiv$ dielectric constant $K > 1$

water $K = 80.4$

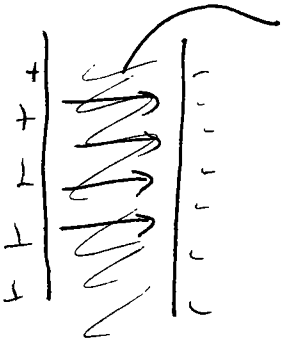
Air $K = 1.00054$

Vacuum $K \equiv 1$

Oil $K = 4.5$

Fields are affected by Medium

effect is medium-dependent



$$E = \frac{\sigma}{\kappa \epsilon_0}$$

$$dV = -\vec{E}\cdot d\vec{s}$$

$$|\Delta V| = V_{\text{between plates}} = \frac{\sigma}{\kappa\epsilon_0} d = \frac{Q}{A}\frac{d}{\kappa\epsilon_0}$$

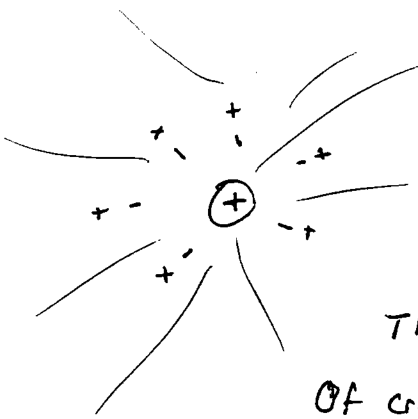
Earlier, w/ no dielectric

$$Q = CV \qquad C \text{ was } \frac{\epsilon_0 A}{d}$$

Now $$C = \frac{\kappa \epsilon_0 A}{d}$$

capacitance is increased!

~~Also~~ for a pt charge imbedded in dielectric



$$E \to \frac{1}{4\pi\kappa\epsilon_0}\frac{Q}{r^2}$$

$\epsilon_0 \nearrow \kappa\epsilon_0$

This is all I will say.

Of critical importance to biology + chemistry

This is something you must deal w/ in real world

real solutions, real gasses, real cells, real expts.

This is the source of all sorts of impt optical effects!

~~However it isn't on the MCATS ∴ so I won't spend more lecture time on it.~~

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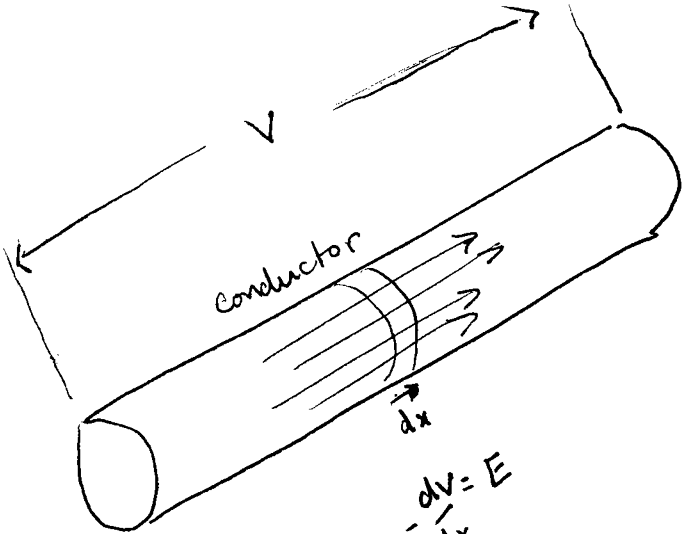
# Current and Circuits




Length $\Delta x$

use $V$ in place of $\Delta V$ ≡ conventional way to simplify notation

$$-\frac{dV}{dx} = E$$

$E$ for uniform wire

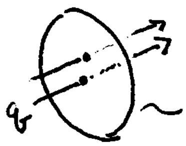
$$E = \frac{V}{L}$$

Charge flows

(Actually electrons

but convention is "+"

Direction of "+" charge flow is + "




~ x section of wire

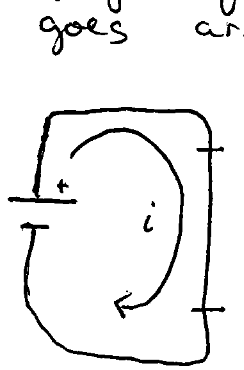
$$\frac{dq}{dt} \equiv \text{current } i$$

$i$ is (+) in direction of + charge flow

~~If no other source~~

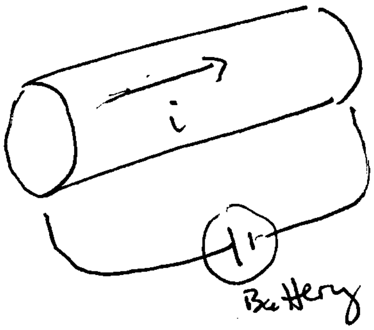
If little conductor section is isolated Then charge flows until field due to induced charges cancels initial imposed field

If not isolated but part of a circuit — charge goes around and around




} our length of wire

Current units : $1 \text{ Ampere} = \frac{1 \text{ Coulomb}}{1 \text{ Second}}$




charge is NOT continuously accelerated

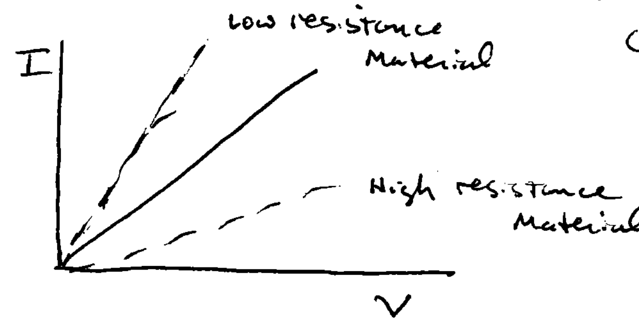
~~get a steady state equilibrium between i induced by $\vec{E}$ and lattice atoms~~

little collisions w/ atoms in the conductor lattice
Transfer energy from moving charges to the lattice
(vibration + heat)

For given material get certain i for given V

For ohmic materials — $i \propto V$ or $V = iR$ ← Resistance

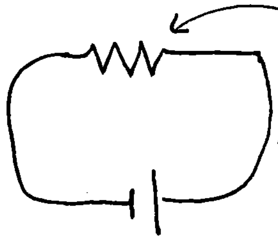
$1\ \Omega \equiv 1 \frac{\text{Volt}}{\text{Ampere}}$ (ohm)




All materials have resistance
except something called a "superconductor"

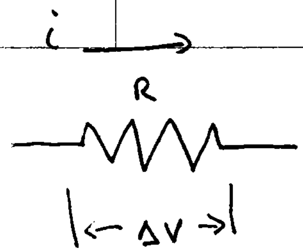
Except when explicitly said in problem - assume
metal conductors - wires to have no/low resistance

Circuit Diagram



← symbol for resistor

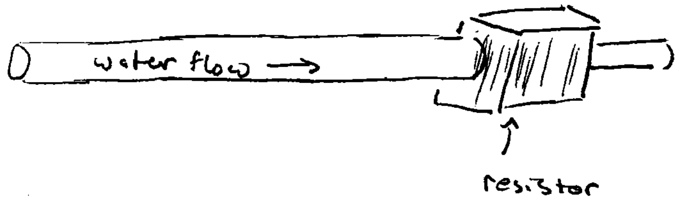
← wire w/ no resistance

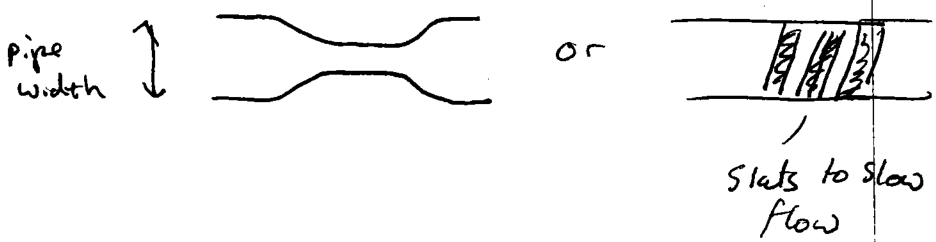



$\Delta V = V = iR$

V is said to be the "potential drop across the resistor"

useful analogy for circuits




$\frac{W}{q} = V$ across resistor

$W = qV$

$\frac{dW}{dt} = \frac{dq}{dt} V \implies P = iV$

Power = (Current)(Voltage)

Power: dissipated in resistor

Voltage: across resistor

also $V = iR$ $\longrightarrow$ $P = i^2 R$

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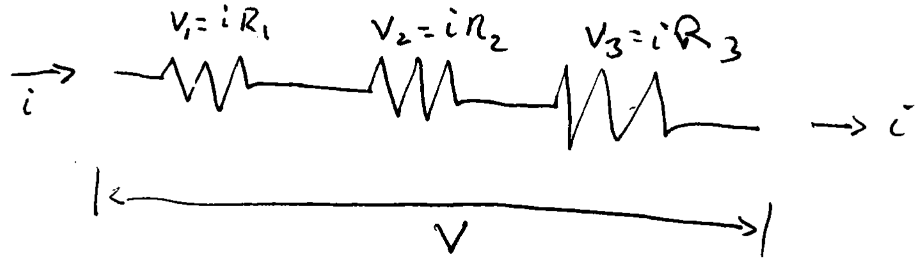
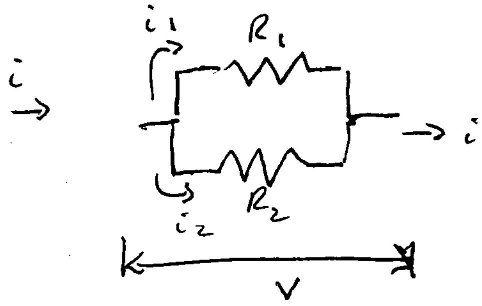
# Combinations of Resistors




$$V = V_1 + V_2 + V_3 = i(R_1 + R_2 + R_3)$$

Resistors in series: $R = R_1 + R_2 + R_3$




$$i = i_1 + i_2$$

$$V = iR$$

$$V = V_1 = i_1 R_1$$

$$V = V_2 = i_2 R_2$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

Resistors in Parallel ⟶ $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

## Batteries and EMF

Batteries + Generators : able to maintain

≡ Seats of electromotive force